PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 09 August 1999 (09.08.99)	
International application No. PCT/US97/24211	**Applicant's or agent's file reference** RCA 86464
International filing date (day/month/year) 29 December 1997 (29.12.97)	**Priority date** (day/month/year)
Applicant ALTMANSHOFER, Robert, Dale et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

08 July 1999 (08.07.99)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer S. De Michiel
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

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NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

TRIPOLI, Joseph, S.
Thomson Multimedia Licencing Inc.
P.O. Box 5312
Princeton, NJ 08543
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year) 09 August 1999 (09.08.99)	
Applicant's or agent's file reference RCA 86464	**IMPORTANT NOTIFICATION**
International application No. PCT/US97/24211	**International filing date** (day/month/year) 29 December 1997 (29.12.97)

1. The following indications appeared on record concerning:

[ ] the applicant [ ] the inventor [X] the agent [ ] the common representative

Name and Address

TRIPOLI, Joseph, S.
GE & RCA Licensing Management Operation Inc.
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State of Residence:
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Facsimile No.: 1 609 734 9700
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [ ] the name [X] the address [ ] the nationality [ ] the residence

Name and Address

TRIPOLI, Joseph, S.
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Telephone No.: 1 609 734 9650
Facsimile No.: 1 609 734 9700
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[X] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer S. De Michiel
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

tripoli, Joseph S. et al
THOMSON MULTIMEDIA LICENSING INC.
P.O. Box 5312
Princeton, New Jersey 08543
ETATS-UNIS D'AMERIQUE

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	02.02.00
Applicant's or agent's file reference: RCA 86464	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US97/24211	29/12/1997	29/12/1997

Applicant
THOMSON CONSUMER ELECTRONICS, INC. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Stannartz, B Tel.+49 89 2399-8242

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
RCA 86464		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US97/24211	29/12/1997	29/12/1997
International Patent Classification (IPC) or national classification and IPC H04N9/64		
Applicant THOMSON CONSUMER ELECTRONICS, INC. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
08/07/1999	02.02.00
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Loeser, E Telephone No. +49 89 2399 8482

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US97/24211

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1-9 as originally filed

Claims, No.:

1-8 as received on 17/12/1999 with letter of 15/12/1999

Drawings, sheets:

1/4-4/4 as originally filed

2. The amendments have resulted in the cancellation of:

☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-8
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-8
Industrial applicability (IA)	Yes:	Claims	1-8
	No:	Claims	

2. Citations and explanations

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

1. General

The present application does not satisfy the criteria set forth in Articles 6 and 33(3) PCT. Details of the objections are set out below.

2. Concerning Section VIII - Art. 6 PCT:

According to claim 3, approximations of sine and cosine are used as control signals inputted to the signal processor. According to claim 6 that depends upon claim 3 via claim 5, sine and cosine functions are used as such rather than the approximations specified in claim 3. The subject-matter of claim 6 is obscured by this discrepancy.

3. Concerning Section V - Articles 33(2) and 33(3) PCT

The application on file relates to changing hue of a colour signal represented by two colour difference signal components while keeping saturation unchanged and using a single control variable.

The following documents are cited - the numbering will be adhered to in the rest of the procedure:
D1: DE-A-3 809 967;
D2: EP-A-0 221 254;
D3: DE-A-3 545 113;
D4: U. Tietze et al: Halbleiterschaltungstechnik. Springer-Verlag Berlin Heidelberg New York, 1980, p.213.

Document D4 was not cited in the international search report. A copy of the document is appended hereto.

3.1. Claim 1

Document D1 discloses circuits for processing colour difference signals so as to emphasize colour differences by way of increasing colour saturation and/or modulating hue, for a colour that slightly differs from another colour, so as to enable improved colour distinction with respect to medical images (Figs. 3, 17). Fig. 26 discloses limiting the amplitudes of RGB signal components derived from the emphasised colour difference signals to a range between 0 and 0.7 V. However, limiting will only happen in cases where the respective components exceed a threshold; limi-

ting is substantially different from maintaining saturation constant as underlying the application on file. Therefore, D1 does not appear to be of particular relevance.

Document D2 (eg p.2 lines 1-18; Figs. 2, 3, 13 and related text passages) discloses adjusting the hue of a colour component signal using colour difference signals and a single control voltage VTIN for rotating the hue angle /"turning the vector plane for the colour signal around the origin". The latter statement indicates that there is no intention to modify colour saturation while rotating the hue angle. Therefore, the objectives underlying the application on file and D2 are the same.

Fig. 13 of D2 also discloses using LUT ROMs for generating two different control signals, the control signals being sine and cosine functions, ie non-linear functions, respectively. The preamble of claim 1, and the non-linear functions mentioned in the characterizing portion of claim 1 on file reflect the prior art disclosed by D2.

It is to be noted that claim 1 specifies the claimed signal processor as being susceptible to "a control signal". However, according to the description (cf Figures), there are two different control signals generated and applied to the signal processor, which two control signals can be considered in conjunction as a complex control signal. The feature "a control signal" is considered acceptable using such an interpretation. The same situation, ie two control signals that can be considered to form a complex control signal, is found in D2.

Document D3 discloses circuits that fully correspond to those disclosed by D2.

The subject-matter of claim 1 differs from the disclosure of D2 by specifying the control means as providing linear approximations of non-linear functions as control signals, and using such approximations for controlling the claimed signal processor.

According to D4, the person skilled in the art has been aware of the fact that when non-linear functions, such as trigonometric functions (eg the sine function) need to be implemented, such functions can be linearly approximated (key words: linear approximation, piecewise linear approximation). Therefore, the skilled person starting with the design of D2 and seeking for design alternatives would have taken into account the teachings

of D4 to arrive at the subject-matter of claim 1 without exercise of an inventive step.

Likewise, the subject-matter can be considered obvious from a combination of D3 and D4.

Hence, claim 1 meets the requirements set out in Art. 33(2) PCT, but infringes Art. 33(3) PCT.

3.2. Dependent Claims

The effective additional features of claim 2, ie the specification of sine and cosine functions as the precedingly claimed non-linear functions, are anticipated by D2 (Figs. 3, 13, 14 and related text passages). These findings also apply to claim 6.

The additional subject-matter of claim 3 is obvious from the disclosures of D2 and D4. The specific values for the coefficients K1 and K2 selected in claim 3 are obvious design options that the skilled person would have considered in accordance with his particular needs. The selected values do not provide any unexpected effect. These findings also apply to claim 7.

The additional subject-matter of claim 4 does also not extend beyond what the skilled person would have considered when implementing the design disclosed by D2 while taking into account the teachings of D4. These findings also apply to claim 8.

The circuitry specified in claim 5 reflects Fig. 5 on file. This circuitry is anticipated by D2 (Fig.2).

Accordingly, each of the dependent claims fails to establish an inventive step as required by Art. 33(3) PCT.

4. **Concerning Section VII: Description and other belongings**

a) Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D2, D3 and D4 is not mentioned in the description, nor are these documents identified therein.

b)

References to "the spirit of the invention" in the description tend to obscure the claims' scope of protection and are

superfluous.

c) The two-part form of claim 1 does not correctly represent the closest prior art (D1) in the preamble, Rule 6.3(b)i) PCT. This is because the use of non-linear functions disclosed by D2 is presently found in the characterizing portion, only. It is considered appropriate to include in the preamble the features pertaining to non-linear functions, and to keep only the feature pertaining to approximation of non-linear functions in the characterizing portion.

CLAIMS

1. Apparatus comprising:

control means for selecting a particular hue characteristic of a video image within a range of selectable hue characteristics; and

a signal processor coupled to said control means for processing first and second color difference signals for controlling a hue characteristic and a saturation characteristic of a video image so that said saturation characteristic has a substantially constant magnitude over said range of selectable hue characteristics.

2. The apparatus of claim 1 wherein the signal processor modifies the first and second color difference signals as a function of each other and as a function of a hue shift angle to produce modified first and second color shift difference signals representing a color vector whose amplitude stays substantially constant over a relatively wide range of hue shift angles.

3. The apparatus of claim 2 wherein the signal processor comprises a control signal generator for generating first and second control signals for controlling generation of said first and second modified color difference signals; each of said first and second control signals representing a non-linear function of the hue shift angle.

4. The apparatus of claim 3 wherein the signal processor comprises first, second, third, and fourth multipliers and first and second adders; the first color difference signal being provided to a first input of the first multiplier and to a first input of the third multiplier; the second color difference signal being provided to a first input of the second multiplier and to a first input of a fourth multiplier; the first control signal being provided to a second input of each of the first and fourth multipliers; the second control signal being provided to a second input of each of the second and third multipliers; an output of the first multiplier and an output of the second multiplier being coupled to respective inputs of a first adder for summing the outputs of the first and second multiplier for producing a first modified color difference signal; an output of the third multiplier and an output of the fourth multiplier being coupled to respective inputs of a second adder for subtracting the output of the fourth multiplier from the output of the third multiplier for producing a second modified color difference signal; the first and second modified

color difference signals representing a color vector having substantially constant amplitude over a wide range of hue shift angles.

5. The apparatus of claim 3 wherein the control signal generator comprises a lookup table ROM for providing values of the first and second control signals representing the respective non-linear functions of the hue shift angle over a wide range of hue shift angles.

6. The apparatus of claim 3 wherein the control signal generator generates the first and second control signals in accordance with respective linear approximations of the respective non-linear functions of the hue shift angle.

7. The apparatus of claim 5 wherein the non-linear functions of hue shift angle represented by the first and second control signals are sine and cosine functions.

8. The apparatus of claim 6 wherein the non-linear functions of hue shift angle represented by the first and second control signals are sine and cosine functions.

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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A1

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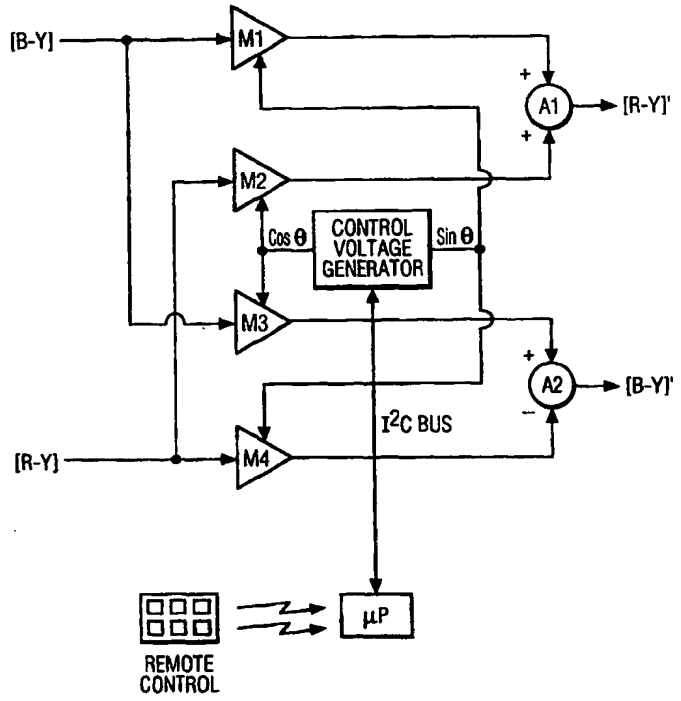
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: COLOR DIFFERENCE HUE CONTROL SYSTEM

(57) Abstract

A color television receiver system processes color difference signals for providing tint control while maintaining uniform color amplitude with respect to changes in hue shift angle. The color difference signals are modified as a function of each other and as a function of a hue shift angle to produce modified color difference signals. A color difference signal [B–Y] is supplied as a first input to multipliers M1 and M3. Another color difference signal [R–Y] is supplied as a first input to another pair of multipliers M2 and M4. A control signal generator produces output signals sin θ and cos θ where θ is the hue shift angle. The sin θ signal is supplied as a second input to multipliers M1 and M4 while the cos θ signal is supplied as a second input to multipliers M2 and M3. The outputs of M1 and M2 are added in an adder A1 to produce a modified output [R–Y]'. Similarly, the output of multiplier M3 is provided as a positive input to adder A2 whereas the output of multiplier M4 is provided as a negative input to adder A2 to produce a modified color difference signal [B–Y]'. The modified color difference signals [R–Y]' and [B–Y]' represent a color vector having an amplitude A that remains substantially constant over a relatively wide range of hue shift angles θ.



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COLOR DIFFERENCE HUE CONTROL SYSTEM

FIELD OF THE INVENTION

The invention relates to control systems for controlling video signal characteristics.

BACKGROUND

In traditional NTSC color television receivers, the television viewer controls the hue of the color by phase shifting the subcarrier reference signals applied to chroma demodulators. This results in a rotation of the "phase plot" of the chroma signal with an attendant hue shift of the demodulated color difference signals. This is illustrated, for example, in Fig. 1 showing the results from rotation of a "phase plot" of a chroma signal with the attendant hue shift of the demodulated color difference signals in the context of a traditional NTSC color television receiver. Several representative colors, namely, red, blue and green, are illustrated in a polar plot. It should be noted that the chroma amplitude represented by the length of the color vectors is substantially unaltered by the hue shift.

The foregoing worked well in the context of traditional NTSC color television receivers, but with advances towards IDTV, EDTV and HDTV as well as evolutions in PAL and SECAM towards customer controls like NTSC products, it becomes desirable to accomplish color (i.e. saturation) and tint (i.e., hue) controls on the base band color difference signals themselves.

The prior art includes a number of efforts to adjust color hue and saturation in a variety of different contexts. One example is described in U.S. Patent 4,788,586 issued on November 29, 1988 to Robert R. Eckenbrecht and entitled "Controller for Adjusting Color Hue and Saturation of Images Generated from Signals in a Non-Broadcasting Video System." Eckenbrecht describes a color tint controller for a closed circuit video system which receives red and blue color difference signals and selectively changes the amplitude of those signals to adjust the color of a displayed image. Other U.S. patents that may be relevant to the adjustment of hue and color saturation include U.S. Patent Nos. 4,528,586; 4,554,576 and 4,562,460.

Controlling tint by processing color difference signals may cause a problem. Specifically, processing color difference signals for providing tint control over a wide range of hue shift angles may result in undesirable color amplitude variations.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention, the invention involves providing for selecting a particular hue characteristic within a range of selectable hue characteristics and processing color difference signals for controlling a hue characteristic and a saturation characteristic of a video signal so that the saturation characteristic has a substantially constant amplitude over the range of selectable hue characteristics.

In accordance with another aspect of the invention, color difference signals are modified as a function of each other and as a function of a hue shift angle θ to produce modified color difference signals representing a color vector whose amplitude stays substantially constant over a relatively wide range of hue shift angles θ.

In accordance with another aspect of the invention, a first color difference signal provides a first input to a first multiplier circuit and to a first input of a third multiplier circuit. A second color difference signal provides a first input to a second multiplier circuit and to a first input of a fourth multiplier circuit. A control signal generator produces a pair of control signals that are each sinusoidal functions of the hue (i.e., tint) shift angle θ. The first control signal is provided as a second input to each of the first and fourth multipliers. The second control signal is provided as a second input to each of the second and third multipliers. Outputs of the first and second multipliers provide a pair of positive inputs to a first adder circuit whose output produces a first modified color difference signal. An output from the third multiplier provides a positive input to a second adder and the output from the fourth multiplier provides a negative input to the second adder. The output of the second adder produces a second modified color difference signal. The first and second modified color difference signals represent a color vector having substantially constant amplitude over a wide range of hue shift angles.

In accordance with another aspect of the invention, the control signal generator includes a lookup table for providing values of the first and second control signals that are a sinusoidal function of the hue shift angle over a wide range of hue shift angles.

In accordance with another aspect of the invention, the control signal generator provides a linear approximation of a sinusoidal function of the hue shift angle for generating the control signal values.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be explained with reference to the drawing in which:

Fig. 1 is a diagram showing the results of the rotation of the phase plot of a modulated chroma signal and the attendant hue shift of the associated demodulated color difference signals in a video signal processing system;

Fig. 2 shows an embodiment of an analog or digital apparatus for modifying color difference signals in such a way that modified color difference signals produced at the output represent a color amplitude that remains relatively constant over a range of hue shift angles;

Fig. 3 is a diagram illustrating how the amplitudes of the color vectors remain relatively constant as the hue shift angle θ varies;

Fig. 4 is a schematic illustration of a second embodiment of the invention;

Fig. 5 is a schematic diagram of another embodiment of the invention; and

Fig. 6 is a diagram illustrating the manner in which the amplitude A of the color signal can be kept substantially constant over a wide range of hue shift angles.

DETAILED DESCRIPTION

During the course of this description, like designations or numbers will be used to identify like elements according to the different figures which illustrate the invention.

Fig. 2 is a block diagram illustrating an embodiment of a tint control system which operates as shown by the vector plot of Fig. 3.

The system shown in Figs. 2 and 3 are linear which result in vector summation of the [R-Y] and [B-Y] components. As a result, the amplitude of the resulting output vector, i.e., the color amplitude or saturation characteristic of the color vector, changes as a function of the hue control setting. For a 45° hue shift θ from nominal, the output amplitude increases approximately 40%. An embodiment providing compensation for this effect is illustrated in the block diagram of Fig. 5. Ideally, it is desirable for the output to remain of constant amplitude

versus the hue control voltage. It has been discovered that it is possible to compensate for amplitude changes over a wide range of hue shift angles by controlling the color saturation by coupling the absolute value change of the hue control voltage from nominal into the color control. A detailed explanation of the compensation feature follows.

A color vector V can be defined as:

$$V \equiv A \angle\theta$$

having an amplitude (color or saturation) A and a phase (or hue) angle θ.

A phase shifted vector V' having the same amplitude A can be defined as:

$$V' \equiv A \angle\theta + \theta'$$

where θ' is the change in phase or hue which would result from a change of the hue control.

In a color difference representation having an [R-Y], [B-Y] coordinate system (X and Y axes, respectively, in the color difference plane), the components of vectors V and V' are then:

$$[R\text{-}Y] = A \sin\theta \qquad [1]$$

$$[B\text{-}Y] = A \cos\theta \qquad [2]$$

and

$$[R\text{-}Y]' = A \sin(\theta + \theta') \qquad [3]$$

$$[B\text{-}Y]' = A \cos(\theta + \theta'). \qquad [4]$$

The following identities:

$$\sin(X + Y) = \sin X \cos Y + \cos X \sin Y; \text{ and}$$

$$\cos(X + Y) = \cos X \cos Y - \sin X \sin Y,$$

make it is possible to rewrite [3] and [4] using [1] and [2] as:

$$[B\text{-}Y]' = \cos\theta'[B\text{-}Y] - \sin\theta'[R\text{-}Y] \quad [5]$$

and

$$[R\text{-}Y]' = \sin\theta'[B\text{-}Y] + \cos\theta'[R\text{-}Y]. \quad [6]$$

Equations [5] and [6] represent the [R-Y] and [B-Y] components of a rotated vector V' in the color difference plane having the same amplitude A as the non-rotated vector V. Equations [5] and [6] show that it is possible to keep the amplitude of rotated vector V' constant by multiplying (gain controlling) each of the [R-Y] and [B-Y] color difference components by a value that is a function of the hue shift angle θ' before combining the [R-Y] and [B-Y] components to produce modified color difference components $[R\text{-}Y]'$ and $[B\text{-}Y]'$. The multiplication or gain control factor in equations [5] and [6] is related to the hue shift angle θ' by a non-linear function, i.e., sinusoidally related to the hue shift angle . That is, the modified color difference signals $[R\text{-}Y]'$ and $[B\text{-}Y]'$ that represent the shifted vector V' are combinations of the original color difference components [R-Y] and [B-Y] modified by sinusoidal functions of the hue shift angle.

As explained further below, in a digital implementation, a ROM lookup table can be used to implement the sinusoidal functions, i.e., provide sine and cosine values corresponding to each value of θ'. Using precise sine and cosine values from a lookup table permits implementing the ideal relationships set forth in equations [5] and [6]. As a result, it is possible to maintain the amplitude of the rotated vector, i.e., the saturation characteristic, substantially constant over the full range of selectable hue shift values. Alternatively, only a limited range hue shift angles θ' may be needed. If so, approximations for non-linear functions such as sine and cosine may be used. For example, it is possible to use the following linear approximations for sine and cosine:

$$\cos\theta' \rightarrow 1 - K_2|\theta'| \text{ and}$$

$$\sin\theta' \rightarrow K_1\theta'$$

where K_1 and K_2 are constants. θ' is now the target phase shift in degrees due to the use of the approximations.

Using these approximations in equations [5] and [6] produces:

$$[\overline{B\text{-}Y}]' = (1 - K_2|\theta'|)\,[B\text{-}Y] - K_1\theta'[R\text{-}Y] \qquad [7]$$

and

$$[\overline{R\text{-}Y}]' = K_1\theta'[B\text{-}Y] + (1\text{-}K_2|\theta'|)[R\text{-}Y] \qquad [8]$$

where $[\overline{R\text{-}Y}]'$ and $[\overline{B\text{-}Y}]'$ are approximations of modified color difference components that represent the ideally rotated vector V' having the following amplitude and phase:

$$\overline{A}' = \sqrt{([\overline{R\text{-}Y}]')^2 + ([\overline{B\text{-}Y}]')^2} \qquad [9]$$

and

$$\overline{\theta}' = \tan^{-1}\left[\frac{[\overline{R\text{-}Y}]'}{[\overline{B\text{-}Y}]'}\right] \qquad [10]$$

If K_2 is equal to or approaches 0, it can be seen that the relationships in equations [7] and [8] become effectively the same as those implemented by the circuit of Fig. 2.

Fig. 6 illustrates the result of comparing the embodiment of Fig. 2 with the embodiment illustrated in Fig. 5. For the embodiment in Fig. 5, the values for K_1 and K_2 are:

$$K_1 = 0.78/45 \quad \text{and} \quad K_2 = 0.21/45$$

for θ in degrees. As shown in Figure 6, the embodiment of Fig. 2, where K_1 equals 0.77/45 and K2 equals 0, produces a change of approximately 16% in the color amplitude vector when the range of hue shift angles is at $\pm$ 30°. The embodiment in Fig. 5, however, where K_1 equals 0.78/45 and K_2 equals 0.21/45, produces an amplitude variation of 3.4% over the same $\pm$ 30° hue shift angle variation.

The values K_1 and K_2 are determined empirically using an exemplary computer program written in QBASIC that is shown in Table 1. An example of the optimization procedure performed by the program follows. K_1 and K_2 in equations [7] and [8] are used in linear approximations of sine and cosine functions. As such, θ in equations [7] and [8] is only a target for the tint shift. The actual resulting tint shift is given by equation [10]. Solving for K_1 and K_2 involves first bounding K_1 and K_2 to some reasonable values. In the program shown in Table 1, certain boundary conditions and iteration step sizes are used, but other values for the boundary conditions and step sizes are possible. Specifically, in the program shown in Table 1, the boundary values used for K_1 are 0.5/45 to 0.8/45 and for K_2 are 0.1/45 to 0.7/45. The program steps the target tint range of θ over a broad range of $\pm 75^{\circ}$ in 5° steps. For each step, the program loops through possible combinations of K_1 and K_2 finding the combination which gives the minimum amplitude change across a range which is less than or equal to the desired tint range value (see parameter "TintRangeDesired" in line 250 of the program in Table 1). The program outputs optimum values for K_1 and K_2.

Fig. 4 illustrates an embodiment of a control system incorporating both color and tint functions. Amplifiers Al and A2 are gain controlled differential output amplifiers having at least one current source output each. Amplifiers Al and A2 accomplish the color control (gain) function and by virtue of the current mode outputs which allow summers S1 and S2 to operate efficiently. Amplifiers Al and A2 could alternatively be two-quadrant multipliers. The differential outputs are necessary to provide one output as a color controlled input to the tint multiplier and the other as the output for summation of currents from the cross-coupled (tint) multipliers. The multipliers M1 and M2 are preferably four quadrant devices having current mode outputs for accomplishing the required summations.

In an embodiment shown in Fig. 5, a first color difference signal [B-Y] is fed as a first input to multipliers M1 and M3. A second color difference signal [R-Y] is fed as another first input to a second pair of multipliers M2 and M4. A control signal generator produces a pair of outputs comprising $\sin\theta$ and $\cos\theta$ from the original hue shift angle θ. $\sin\theta$ provides a second input to multipliers to M1 and M4, whereas $\cos\theta$ provides a second input to multipliers M2 and M3. The outputs of multipliers M1 and M2 provide a first and second positive input, respectively, to adder A1 which produces a first modified color difference signal [R-Y]'. Similarly, the output from multiplier M3 provides a first positive input to adder A2, whereas the

output from multiplier M4 provides a second, negative input to adder A2 which produces, as a result, a second modified color difference signal [B-Y]'. The modified color difference signals [R-Y]' and [B-Y]' replace the original color difference signals [R-Y] and [B-Y] in a video signal processing system to provide a tint controlled video signal. When employed in this fashion, the color chroma vector amplitude A remains at a substantially constant value over a wide range of hue shift angles θ.

The control signal generator in Fig. 5 produces control signals representing hue shift values that can be controlled, e.g., by a user-controlled tint control. For example, Fig. 5 shows a microprocessor (uP) coupled to the control signal generator via a data bus such as the well-known IIC or I2C data bus. The microprocessor receives and processes commands from a user-operated remote control. In a typical television system, in response to a user activation of a particular key of the remote control, the microprocessor will generate a graphics display signal that when coupled to a display device (not shown in Fig. 5) will produce, for example, a displayed menu (on-screen display or OSD) from which a user can select to control certain characteristics of the television system. One such characteristic is tint. After selecting tint control from the OSD menu, the user operates one or more keys of the remote control to vary the tint setting. The microprocessor detects the remote control signals indicating the tint modifications and generates the required control signals on the I2C bus to cause the control signal generator to generate control signals $\sin\theta$ and $\cos\theta$ that produce the desired tint modification.

The functions of the multipliers M1 - M4, summers S1 and S2, adders Al and A2 and the control voltage generator, can be realized using either analog or digital implementations. For example, in a digital implementation, the outputs for the control voltage generator can be generated from a ROM look-up table. In a fully digital system in which the color difference signals are digital data streams, digital multipliers can be used to multiply the color difference signals by the control signal values and digital adders can be used to combine the multiplier outputs to produce digital modified color difference signal data streams. If the color difference signals are analog and analog multipliers and adders are used, the ROM output can be converted to an analog value using a digital to analog converter (DAC). Alternatively, analog control signal generator outputs can be generated from DACs having input registers into which digital values representing the desired hue angle are loaded by the microprocessor via the I2C bus, e.g., the DAC input registers may be memory mapped registers. In an analog system, an

implementation of a control signal generator that could provide approximations of the desired control signal values could be implemented using the non-linearity of transistor and diode junctions. Due to the relative complexity of the control function and the need for plural multipliers, it may be desirable to implement the described embodiments using one or more integrated circuits (IC).

While the invention has been described with reference to the embodiments described herein, it will be appreciated by those of ordinary skill in the art that modifications can be made to the structure and function of the invention without departing from the spirit and scope thereof.

```
10 PI = 4 * ATN(1)
40 MAG1 = 1
50 ANGLE1 = 0
60 TintRangeDesired = 40
CLS
100 RY1 = MAG1 * SIN(ANGLE1 * PI / 180)
110 BY1 = MAG1 * COS(ANGLE1 * PI / 180)
120 MINDELTA1 = 100
130 FOR K1 = .5 / 45 TO .8 / 45 STEP .01 / 45
140 MINDELTA2 = 100
150 FOR K2 = .1 / 45 TO .7 / 45 STEP .01 / 45
160 MAXDELTA = 0
200 FOR THETA = -75 TO 75 STEP 5
210 RY2 = K1 * THETA * BY1 + (1 - K2 * ABS(THETA)) * RY1
220 BY2 = (1 - K2 * ABS(THETA)) * BY1 - K1 * THETA * RY1
230 MAG2 = SQR(RY2 ^ 2 + BY2 ^ 2)
235 IF BY2 = 0 THEN BY2 = 1E-19
240 ANGLE2 = (180 / PI) * ATN(RY2 / BY2)
245 IF ABS(ANGLE2) < 40 AND THETA = -75 THEN THETA = 75: DELTA = 1: GOTO 280
250 IF ABS(ANGLE2) > TintRangeDesired THEN GOTO 280
260 DELTA = ABS(ABS(MAG2) - 1)
270 IF DELTA > MAXDELTA THEN MAXDELTA = DELTA: KP1 = K1: KP2 = K2
280 NEXT THETA
300 IF (MAXDELTA < MINDELTA2) THEN MINDELTA2 = MAXDELTA: KM1 = KP1: KM2 = KP2
310 NEXT K2
400 IF MINDELTA2 < MINDELTA1 THEN MINDELTA1 = MINDELTA2: KL1 = KM1: KL2 = KM2
410 NEXT K1
500 PRINT
510 PRINT
520 PRINT "K1-OPT = "; KL1 * 45, "K2-OPT = "; KL2 * 45
530 END
```

TABLE 1

CLAIMS

1. Apparatus comprising:

control means for selecting a particular hue characteristic of a video image within a range of selectable hue characteristics; and

a signal processor coupled to said control means for processing first and second color difference signals for controlling a hue characteristic and a saturation characteristic of a video image so that said saturation characteristic has a substantially constant magnitude over said range of selectable hue characteristics.

2. The apparatus of claim 1 wherein the signal processor modifies the first and second color difference signals as a function of each other and as a function of a hue shift angle to produce modified first and second color shift difference signals representing a color vector whose amplitude stays substantially constant over a relatively wide range of hue shift angles.

3. The apparatus of claim 2 wherein the signal processor comprises a control signal generator for generating first and second control signals for controlling generation of said first and second modified color difference signals; each of said first and second control signals representing a non-linear function of the hue shift angle.

4. The apparatus of claim 3 wherein the signal processor comprises first, second, third, and fourth multipliers and first and second adders; the first color difference signal being provided to a first input of the first multiplier and to a first input of the third multiplier; the second color difference signal being provided to a first input of the second multiplier and to a first input of a fourth multiplier; the first control signal being provided to a second input of each of the first and fourth multipliers; the second control signal being provided to a second input of each of the second and third multipliers; an output of the first multiplier and an output of the second multiplier being coupled to respective inputs of a first adder for summing the outputs of the first and second multiplier for producing a first modified color difference signal; an output of the third multiplier and an output of the fourth multiplier being coupled to respective inputs of a second adder for subtracting the output of the fourth multiplier from the output of the third multiplier for producing a second modified color difference signal; the first and second modified

color difference signals representing a color vector having substantially constant amplitude over a wide range of hue shift angles.

5. The apparatus of claim 3 wherein the control signal generator comprises a lookup table ROM for providing values of the first and second control signals representing the respective non-linear functions of the hue shift angle over a wide range of hue shift angles.

6. The apparatus of claim 3 wherein the control signal generator generates the first and second control signals in accordance with respective linear approximations of the respective non-linear functions of the hue shift angle.

7. The apparatus of claim 5 wherein the non-linear functions of hue shift angle represented by the first and second control signals are sine and cosine functions.

8. The apparatus of claim 6 wherein the non-linear functions of hue shift angle represented by the first and second control signals are sine and cosine functions.

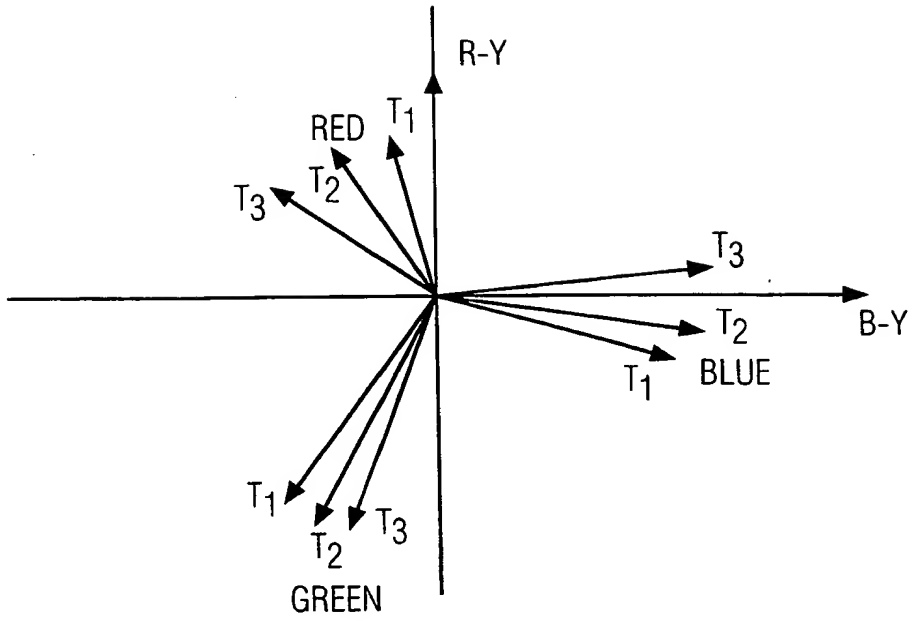
R-Y
RED
T1
T2
T3
T3
T2
T1
B-Y
BLUE
T1
T2
T3
GREEN

FIG. 1

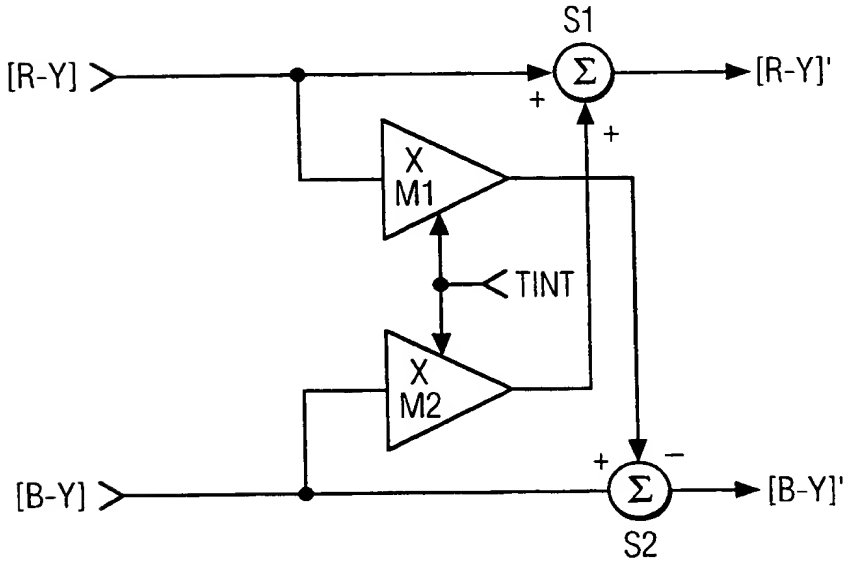
S1
[R-Y]
[R-Y]'
+
+
X
M1
TINT
X
M2
+
−
[B-Y]
[B-Y]'
S2

FIG. 2

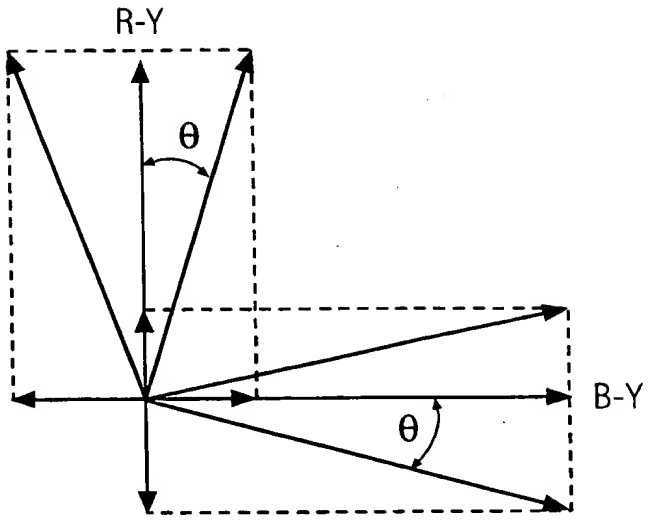

FIG. 3

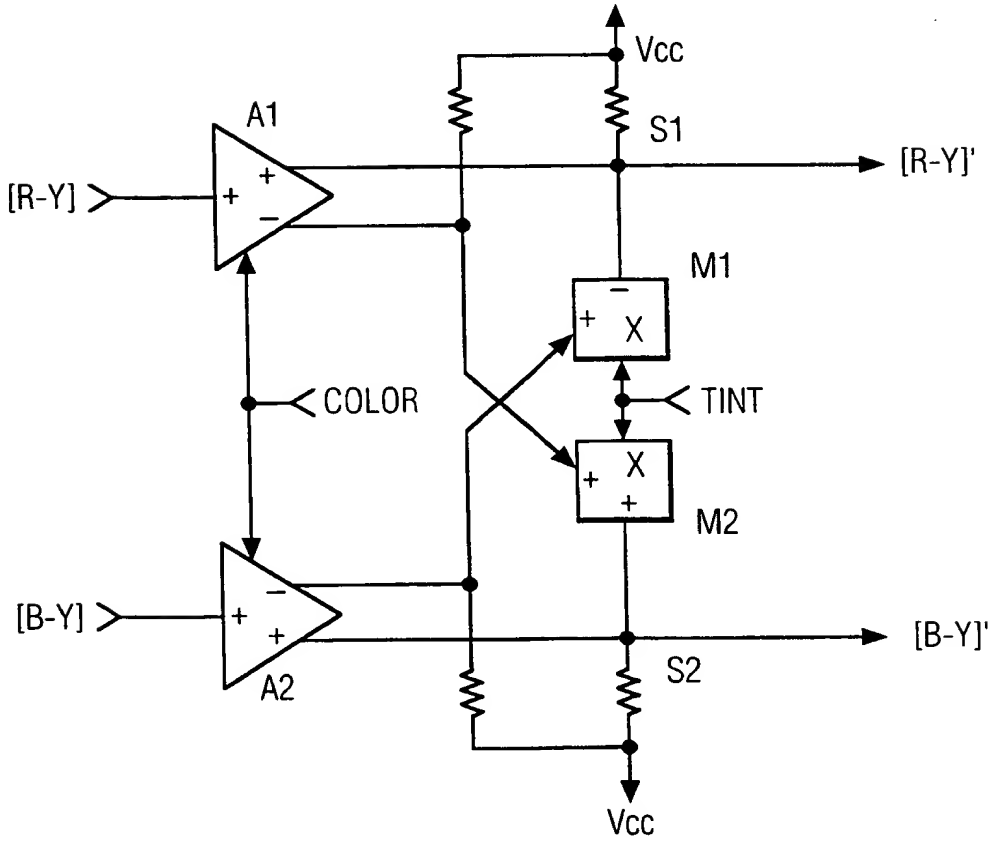

FIG. 4

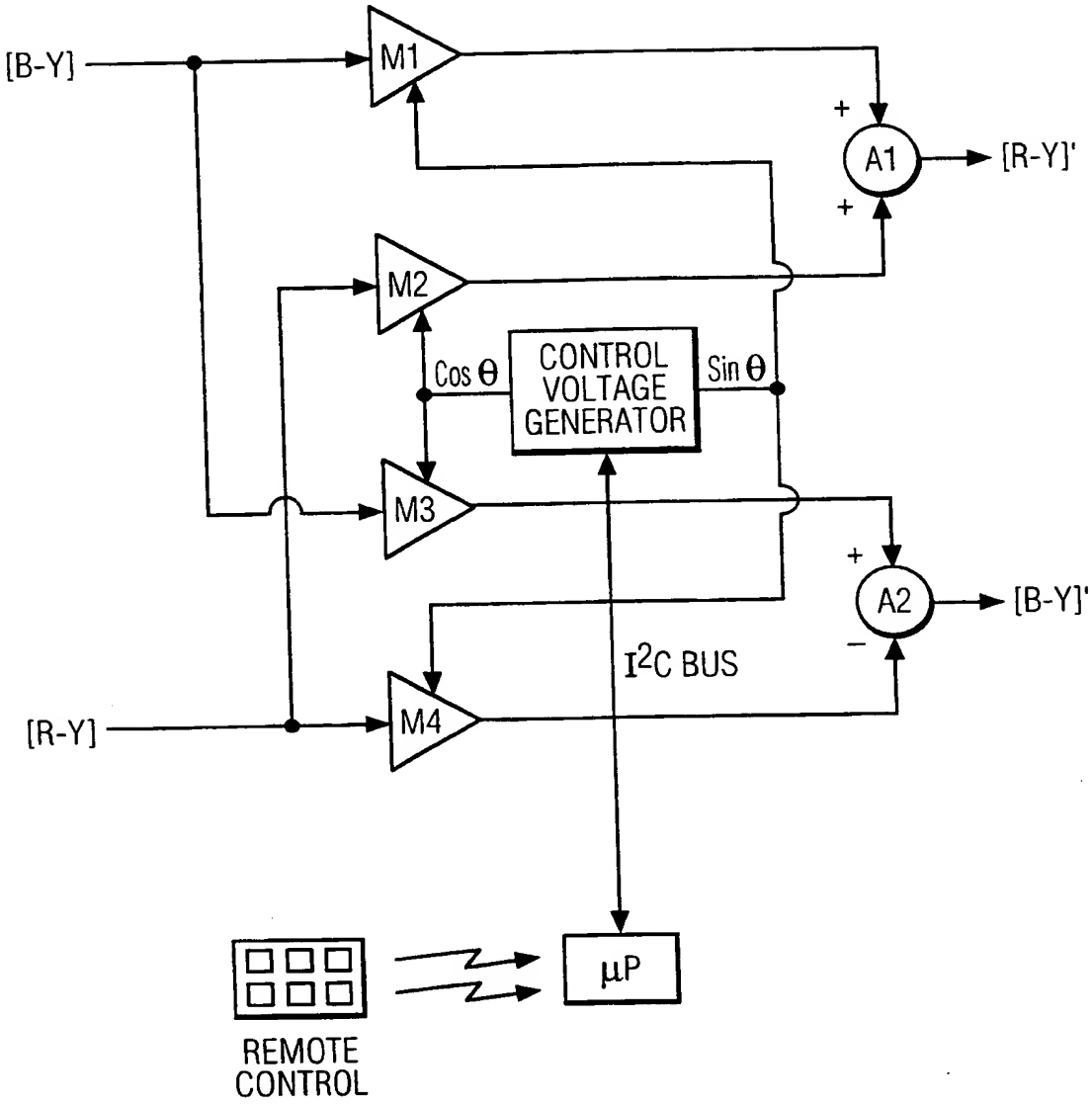
[B-Y]
M1
+
A1
[R-Y]'
+
M2
Cos θ
CONTROL VOLTAGE GENERATOR
Sin θ
M3
+
A2
[B-Y]'
−
I2C BUS
[R-Y]
M4
μP
REMOTE CONTROL

FIG. 5

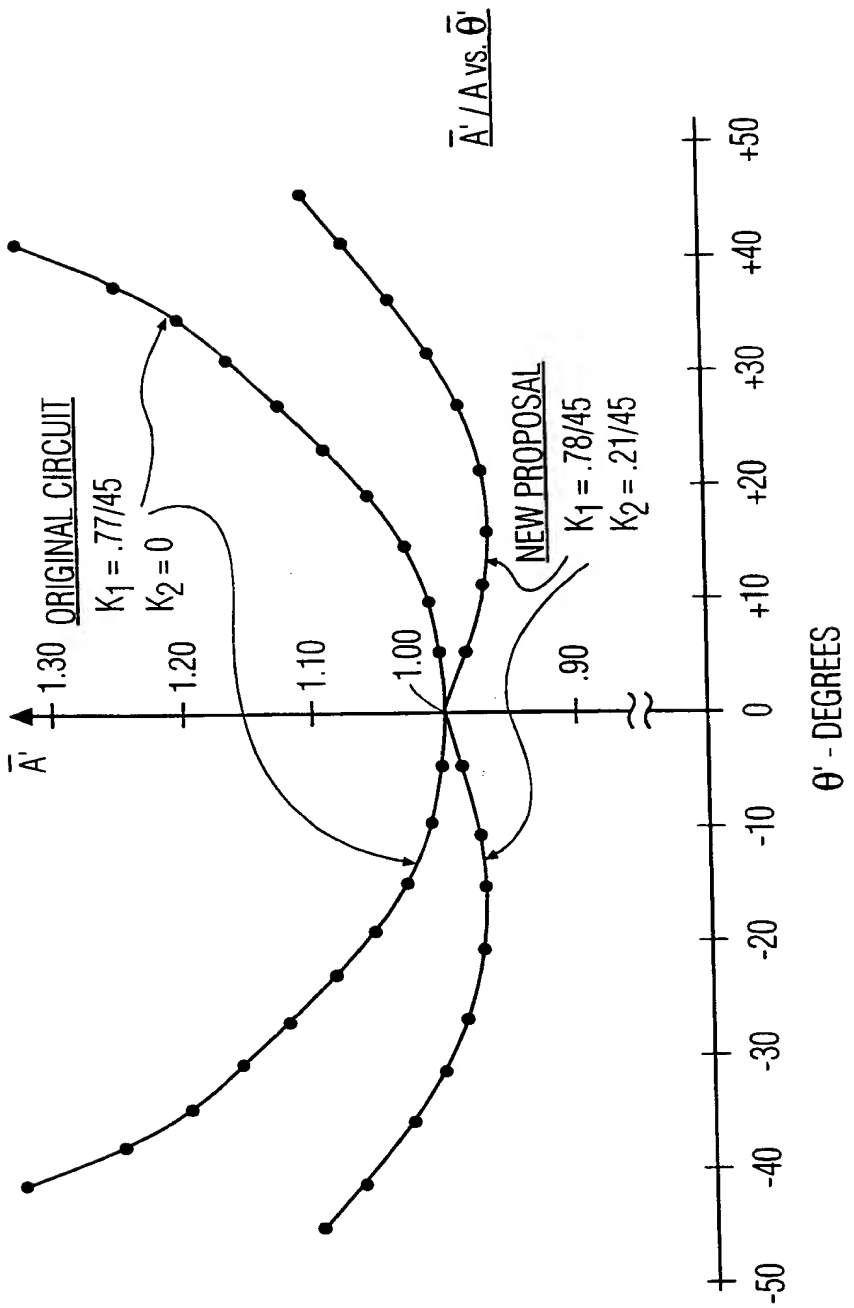
$\bar{A}'/A$ vs. $\bar{\theta}'$
ORIGINAL CIRCUIT
$K_1 = .77/45$
$K_2 = 0$
NEW PROPOSAL
$K_1 = .78/45$
$K_2 = .21/45$
$\bar{A}'$
1.30
1.20
1.10
1.00
.90
0
+10
+20
+30
+40
+50
-10
-20
-30
-40
-50
θ' - DEGREES

FIG. 6

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
RCA 86464		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US 97/ 24211	29/12/1997	
Applicant		
THOMSON CONSUMER ELECTRONICS, INC. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (see Box I).

2. [ ] **Unity of invention is lacking** (see Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] Transcribed by this Authority

4. With regard to the **title,**
   - [X] the text is approved as submitted by the applicant
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   - [X] the text is approved as submitted by the applicant
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this International Search Report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is:
   Figure No. 5
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

In. ational Application No
PCT/US 97/24211

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04N9/64

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 38 09 967 A (OLYMPUS OPTICAL CO.) 13 October 1988 see page 9, line 46 - page 10, line 24	1-8
A	EP 0 221 254 A (HITACHI) 13 May 1987 see page 6, line 19 - page 9, line 26	1-8
A	DE 35 45 113 A (CANON K.K.) 10 July 1986 see page 9, line 36 - page 10, line 36	1-8

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 June 1998	30/06/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Pigniez, T

2

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int ional Application No
PCT/US 97/24211

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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